No. LXXII.

An Anſwer to DR. JOSEPH PRIESTLEY's *Conſiderations on the Doctrine of Phlogiſton, and the Decompoſition of Water; founded upon demonſtrative Experiments.* By JAMES WOODHOUSE, M. D. Profeſſor of Chemiſtry in the Univerſity of Pennſylvania, &c.

SECTION I.

Of the Conſtitution of Metals.

DR. Prieſtley in two late publications, entituled, Conſiderations on the Doctrine of Phlogiſton and Decompoſition of Water, has attacked that theory of chemiſtry, which is at preſent adopted by a large majority of chemiſts, in different parts of the world.

The doctor adheres to the doctrine of phlogiſton, and believes that metals are compound bodies, formed of this ſubſtance and a peculiar baſe or calx.

On the contrary, the antiphlogiſtic chemiſts reject phlogiſton.

Firſt. Becauſe it appears to be a mere creature of the imagination, whoſe exiſtence has never been proved.

Secondly. Becauſe all the phænomena of chemiſtry, can be ſatisfactorily explained, without the aid of this hypotheſis.

They believe metals to be ſimple ſubſtances, becauſe they have never been proved to be compound bodies.

They conſider a metallic calx, to be an union of a metal and the baſe of vital air, called by them oxygen, as it is the principle of univerſal acidity. The proofs that metals, in being converted into calces, abſorb oxygen are,

Firſt. That all the calces of mercury give out oxygenous gas when expoſed to a red heat, without any addition.

Secondly. If a metal is calcined in oxygenous gas, the whole of it will be abſorbed.

Thirdly.

Thirdly. If the proceſs of calcination is performed in a variety of gaſes, containing ſome oxygenous air, the oxygen only will be imbibed by the metal, and the others will be left unaltered.

Fourthly. If any ſubſtance is added to a metallic oxyd, and the calx is revived, a compound body will be produced, formed of the agent uſed and the oxygen contained in the calx.

Thus, if the filings of pure bar iron are mixed with red precipitate, and expoſed to a red heat, the iron will be converted into a calx and the mercury will be revived. If pure charcoal is mixed with the precipitate, carbonic acid will be produced; and if the mercurial calx is revived in hydrogenous gas, water will be formed.

The firſt objection of Dr. Prieſtley, to this theory of the calcination of metals, is as follows.

He ſays, if turbith mineral is expoſed to a red heat, a calx remains which cannot be revived in any degree of heat, without the aid of ſome ſubſtance, ſuppoſed to contain phlogiſton. Before we proceed any further in this inveſtigation, it is abſolutely neceſſary to determine the real compoſition of turbith mineral.

According to the French philoſophers, this ſubſtance is a pure oxyd of mercury.

Fourcroy and Baumé declare, that it does not contain one particle of the ſulphuric acid. Dr. Prieſtley is doubtful whether it is a ſalt or a calx; and in the Edinburgh Diſpenſatory and London Pharmacopœia Chirurgica, it is called hydrargyrus vitriolatus flavus.

The following experiments were made, to aſcertain the compoſition of this ſubſtance.

Firſt. One ounce of pure turbith mineral was expoſed to a red heat, in a long glaſs tube, which communicated with an hydropneumatic apparatus, when thirty-three ounce meaſures of oxygenous gas were obtained. Upon breaking the glaſs, a quantity of fluid mercury was found in the tube.

tube. Two drachms of the ſulphate of mercury, of a white colour and ſtrong acrid taſte, had ſublimed on the ſides of the glaſs. A part of the ſulphate of mercury, was coloured by an immenſe number of minute particles of revived mercury, which gave it the appearance of mercurius cinereus.

Secondly. One ounce of turbith mineral, was boiled fifteen times, ſix hours each time, in half a pint of diſtilled water, which was renewed every time; and it could not be freed from the ſulphuric acid, for the water always precipitated a ſolution of muriated barytes.

Thirdly. One ounce of turbith mineral was boiled three hours, in a ſolution of cauſtic potaſh, when it loſt its yellow colour, and was converted into a calx of the colour of brickduſt. Upon being dried it was found to have loſt one hundred and ſixty grains in weight.

The liquor in which it was boiled, by ſpontaneous evaporation in the open air, gave chryſtals of vitriolated tartar.

Theſe experiments were repeated with turbith mineral, made by precipitating a ſolution of the ſulphate of mercury by potaſh, with the ſame reſult.

They clearly prove, contrary to what has been advanced by Lavoiſier, Monnet, Bucquet, Fourcroy, Chaptal and other French chemiſts, that turbith mineral, is not a pure oxyd of mercury, but contains ſulphuric acid, and may be conſidered as a ſulphate of mercury.

The reaſon that thoſe gentlemen were deceived in regard to the compoſition of this ſubſtance muſt have been, either that they did not break the veſſels in which their experiments were made, to diſcover any reſiduum, or from the circumſtance, of obtaining oxygenous gas from the turbith, equally as good as from any acknowledged calx of mercury.

The reaſon that turbith mineral yields oxygenous gas, when it is expoſed to a red heat is, that the ſulphuric acid quits

quits one part of it and joins to another, which ſublimes in the form of a white ſalt. That part which the ſulphuric acid leaves, is converted into a calx, is revived without addition, and yields oxygenous gas.

This ſulphate of mercury is the ſuppoſed calx, to which Dr. Prieſtley refers. It is ſometimes obtained of a red colour, owing to ſome impure matter contained in the turbith mineral, which by depriving a part of the ſulphuric acid of its pure air, converts it into ſulphur, which uniting with part of the revived mercury, forms cinnabar, which gives the whole of the ſublimed ſalt a red colour.

That it is a ſulphate of mercury, we have an additional proof, from an experiment of Dr. Prieſtley, for he procured ethiops mineral, by heating this ſuppoſed calx in inflammable air, by means of a burning lens, which he could not have obtained from a pure calx of mercury, treated in the ſame manner.

The ſize of the veſſel in which turbith mineral is heated, will vary the reſult of the experiment. No reſiduum can be obtained, by expoſing it in a crucible to a red heat, for the whole of it flies away, and leaves only a mark on the bottom of the veſſel. The ſame circumſtance will take place, if a ſhort glaſs tube is uſed.

Having thus determined, that the ſubſtance which remains after expoſing turbith mineral to a red heat, is a neutral ſalt coloured red by cinnabar, and not a metallic calx, we ſee that the firſt objection of Dr. Prieſtley, to the theory of the calcination of metals, adopted by the antiphlogiſtic chemiſts, loſes all its force, for certainly it does not follow, that becauſe the ſulphate of mercury requires to be deprived of its ſulphuric acid, before running mercury can be procured from it, that therefore all mercurial calces require the addition of phlogiſton, to be converted into mercury.

The

The ſecond objection of Dr. Prieſtley, to the new theory of chemiſtry is, that when a metal is reduced to a calx, it throws out ſomething which forms phlogiſticated air. He ſays, that when the focus of a burning lens, is thrown upon iron confined in atmoſpheric air, the dephlogiſticated air is not merely ſeparated from the phlogiſticated air, but that the phlogiſton from the iron, unites with the dephlogiſticated air and forms azotic gas.

In order to ſee if this aſſertion was juſt, the focus of the burning lens belonging to our ſociety, which is eleven inches in diameter, was thrown upon ninety grains of the filings of bar iron, filed for the purpoſe, confined in thirty-two ounce meaſures of oxygenous gas, which had been well waſhed in lime water, and which was ſo pure, that nearly the whole of it was devoured by the teſt of nitrous air. Twenty-eight ounce meaſures of the pure air were abſorbed by the iron, which was reduced to a calx.

The quantity of carbonic acid produced, which was formed by a ſmall quantity of coal, which all iron of commerce contains, uniting to a part of the pure air, amounted to one ounce meaſure.

When the fixed air was abſorbed by waſhing it in lime water, the remaining air was in no manner injured.

The focus of the lens was likewiſe thrown, upon ſixty grains of the filings of copper, confined in ſixteen ounce meaſures of oxygenous gas. Twelve ounce meaſures of the pure air were abſorbed by the metal, which was converted into a calx. No carbonic acid or azotic gas was formed, and the remaining air was perfectly pure. Theſe experiments prove, contrary to what has been ſaid by Dr. Prieſtley, that when a metal, containing no foreign ſubſtance, is calcined in oxygenous gas, the pure air only is imbibed, no ſubſtance is emitted from the metal, and no azotic gas is formed.

SECTION

SECTION II.

Of the Solution of Iron in the diluted Sulphuric and Muriatic Acids.

The next thing which engages the attention of Dr. Prieſtley, is the ſolution of iron, in the diluted ſulphuric and muriatic acids.

The queſtion to be decided is, whether the hydrogenous gas which is produced, comes from the iron, or from the water which the acids contain.

The antiphlogiſtic chemiſts contend, that it comes from the water, for the following reaſons.

Firſt. If concentrated ſulphuric acid is boiled upon iron filings, ſulphureous gas is produced, but no inflammable air, and the ſulphuric acid ſuffers a decompoſition and a loſs in weight.

Secondly. If the ſulphuric acid is digeſted upon iron in the cold, it remains in a quieſcent ſtate, but the inſtant water is added, a violent action enſues, accompanied by a diſcharge of hydrogenous gas.

Thirdly. They believe that the hydrogenous gas comes from the water, becauſe no inflammable air, can be produced from iron without water, and the hydrogenous gas obtained is in ſtrict proportion to the water, which the acids contain.

Fourthly. They believe, water is decompoſed in diſſolving iron in the diluted ſulphuric acid, that its oxygen calcines the metal, while its hydrogen eſcapes, and that the acid acts upon the calcined metal without being decompoſed, for it will ſaturate as much alkali, after the proceſs of ſolution, as it did before.

Fifthly. They prove that water is compoſed of oxygen and hydrogen.

Dr. Prieſtley's objection to this explanation is, that as one hundred parts of water, according to the advocates of

the new ſyſtem of chemiſtry, are compoſed of eighty-ſeven parts of oxygen and thirteen of hydrogen, which is nearly ſeven times as much of the former as of the latter, there muſt be a great depoſition of oxygen ſomewhere, when iron is diſſolved in the diluted ſulphuric acid, which he cannot diſcover.

He denies that it unites to the metal, and declares there is no addition of oxygen in the proceſs, and conſequently that there is no decompoſition of water in the caſe.

That there is a quantity of oxygen, which unites to the metals, when diſſolved in acids, I think can be eaſily proved.

In order to do this I will ſhew, that when pure metallic calces, which are acknowledged by Dr. Prieſtley to contain oxygen, are heated in hydrogenous gas, that the oxygen of the calces unites to the hydrogen and forms water, and that the diſappearance of the inflammable air, is always in ſtrict proportion to the pure air, which the calces contain.

I will then prove that the calces of copper and iron, obtained from the ſulphates of theſe metals by ammoniac, have this property of making large quantities of inflammable air diſappear. The oxyds which are acknowledged to contain oxygen are mercury, lead and manganeſe.

The focus of the lens was thrown upon two drachms of red precipitate, confined in thirty-two ounce meaſures of hydrogenous gas, obtained from the ſulphuric acid diluted with water and the filings of bar iron, and which had been well waſhed in lime water. Twenty-two ounce meaſures of the inflammable air diſappeared, the mercury was revived and no carbonic acid gas was produced. The air which remained behind was not altered.

According to Dr. Prieſtley, fixed air ſhould have been formed in this proceſs, for he ſays, when any ſubſtance known to contain oxygen, is heated in inflammable air, fixed air is found, but this is not the caſe.

I agree with the Doctor, that carbonic acid gas will be obtained by reviving minium, or mercurius precipitatus per ſe in inflammable air, for theſe calces generally contain it, but if the minium be converted into maſſicot, no fixed air will be generated.

Here we have a ſtrong proof of the poſition we are endeavouring to eſtabliſh.

Two drachms of red lead, make twenty ounce meaſures of inflammable air diſappear, when heated in it by the burning lens, but when converted into maſſicot, only eight ounce meaſures.

Now, if Dr. Prieſtley's theory was true, that the metal imbibed the air, maſſicot ought to abſorb more inflammable air than minium, as it contains more lead than an equal weight of minium.

In making red lead into maſſicot, nothing but pure air with a ſmall quantity of fixed air eſcapes, and the loſs of the pure air is the true reaſon, that one calx of the ſame metal, will make more inflammable air diſappear than another.

But we have ſtill ſtronger proofs, to prove that our ideas on this ſubject are juſt.

The focus of the lens was thrown upon one drachm of the oxyd of manganeſe, confined in thirty ounce meaſures of hydrogenous gas, when twenty-two ounce meaſures of the gas diſappeared, and the metal was not revived. How then could the inflammable air have entered into its compoſition?

A quantity of the oxyd of manganeſe, was expoſed to a red heat for three hours, and a part of its pure air was driven off, when upon throwing the focus of the lens upon one drachm of it confined in inflammable air, none of the air diſappeared, whereas if this quantity of the oxyd, had not been expoſed to a red heat, twenty-two ounce meaſures of the air would have vaniſhed.

Some manganeſe was alſo precipitated from its ſolution, in the muriatic acid by ammoniac, and when freſh made it would never make any inflammable air diſappear, when heated in it by the burning lens, but after being expoſed a few days to the action of atmoſpheric air, one drachm of it made four ounce meaſures of inflammable air diſappear. In all theſe caſes we evidently ſee the operation of oxygen. Not knowing the exact quantity of pure air, which iron and copper abſorbed, one drachm of the filings of bar iron were melted by the burning lens in oxygenous gas when twenty-ſix ounce meaſures were imbibed by the iron, and the ſame quantity of the filings of copper treated in the ſame manner gave an abſorption of thirteeen ounce meaſures.

One drachm of the precipitate of iron, from a ſolution of the ſulphate of iron by ammoniac, was then heated in forty-ſix ounce meaſures of hydrogenous gas, when thirty-ſix ounce meaſures of the air diſappeared.

The ſame quantity of the common ruſt of ſteel, and the carbonate of iron, obtained from green vitriol by a ſolution of mild pot aſh, and what Dr. Prieſtley calls a nitrated calx of iron, formed by adding nitric acid to a calx of iron and expoſing it to a red heat, when treated in the ſame manner, made exactly as much air vaniſh.

One drachm of the precipitate of copper, from a ſolution of blue vitriol by ammoniac, expoſed to the action of the lens in hydrogenous gas, made eighteen ounce meaſures of the air diſappear.

Here then are two metals, one of which the iron, abſorbs twice as much oxygen, when melted in it, as the copper, and its calx following the ſame proportion when heated in hydrogenous gas, makes exactly twice as much of the air diſappear.

After one drachm of the calx of iron, had made thirty-ſix ounce meaſures of inflammable air diſappear, it was expoſed to the action of the lens in oxygenous gas, when four

four ounce meaſures of the air were abſorbed, and after this being again heated in hydrogenous gas, ſix ounce meaſures of the air vaniſhed.

In all theſe experiments nothing but water was produced. The carbonic acid gas was not obtained, unleſs it previouſly exiſted in the calces.

It is not however denied, that fixed air may be generated by heating a pure metallic calx, in a particular kind of inflammable air. Thus it may be made by reviving red precipitate in hydrogenous gas, obtained from expoſing the flowers of zinc and coal to a red heat, or from paſſing alcohol over red hot iron, but none will be procured from that made by the diluted ſulphuric acid and malleable iron, or from that obtained by paſſing the ſteam of water over malleable iron.

Upon reviving three drachms of red precipitate, in thirty-ſix ounce meaſures of hydrogenous gas, from the flowers of zinc and coal, and which had been well waſhed in lime water, there was an abſorption of only two ounce meaſures.

After the operation, there was a great production of carbonic acid gas. Water was not formed in this proceſs, for the coal held in ſolution in the hydrogenous gas, had a ſtronger attraction to the pure, than to the inflammable air, and conſequently fixed air was generated.

Had the ſame quantity of precipitate been revived in inflammable air, from malleable iron, upwards of thirty ounce meaſures of the air would have vaniſhed.

Dr. Prieſtley, ſuppoſing that the inflammable air, or the phlogiſton it contains, enters into the compoſition of the metals, has made a calculation of the quantity of this air abſorbed by an ounce of ſeveral of them. He calculates from the metal actually revived. According to him, one ounce of mercury abſorbs three hundred and ſixty-two ounce meaſures of hydrogenous gas. The quantity mentioned here, is far too great. One drachm of red precipitate, which contains

tains more than fifty grains of mercury, makes twelve ounce meaſures of inflammable air diſappear.

It is a difficult matter to be exact in this experiment, for ſome of the precipitate always diſperſes in reviving the mercury, and a part of the metal ſublimes and adheres to the ſides of the veſſel which is uſed.

As I believe, that when a metallic calx is heated in hydrogenous gas, the oxygen of the calx, unites to the hydrogen and forms water, I always calculate from the quantity of hydrogenous gas that diſappears, from heating a given quantity of a calx in this air.

According to my experiments, one ounce of red precipitate, mercurius precipitatus per ſe, and the calx obtained by boiling a ſolution of cauſtic pot-aſh on turbith mineral, makes 112 ounce meaſures of inflammable air diſappear, when heated in it by the burning lens.

Red Lead	88
Maſſicot	32
Litharge	32
Manganeſe	192
Copper	144
Iron	288

Upon diſſolving half a drachm of the precipitate of iron, which had made ſixteen ounce meaſures of hydrogenous gas diſappear, in diluted ſulphuric acid, as much inflammable air was obtained, as two grains of the filings of malleable iron would have produced. According to this experiment, were I to calculate in the ſame manner as Dr. Prieſtley, I would ſay, that one ounce of bar iron abſorbs 3840 ounce meaſures of inflammable air, but this quantity of the metal by ſolution in the ſulphuric acid and water will yield no more than 365 ounce meaſures of hydrogenous gas.

If an ounce of mercury abſorbs 362 ounce meaſures of inflammable air, it ought to give out this air when diſſolved

ed in an acid, or ſome ſubſtance into which it enters as a conſtituent part. But mercury revived from red precipitate by inflammable air, boiled in ſulphuric acid gives ſulphureous gas, and when added to nitric acid, nitrous air, neither of which contain inflammable air.

It ſhould alſo exhibit ſome properties, when ſubjected to the action of chemical agents, different from that which is revived from a mercurial calx merely by an increaſe of its temperature, which is not the caſe; and if mercury abſorbs inflammable air, that which is revived without addition, when heated in inflammable air, ſhould abſorb ſome of it which it will not do.

It certainly is not probable, that an ounce of mercury containing more than twelve quarts of hydrogenous gas, ſhould have the ſame external appearance, and exhibit the ſame chemical properties, as that which does not contain one particle of this air.

Dr. Prieſtley not only believes, that when red precipitate is heated in hydrogenous gas, the inflammable air enters into the metal, but that, the pure air of the metallic calx is diffuſed through the hydrogenous gas which remains behind.

As a proof of this he mentions an exploſion, which happened from reviving red precipitate, in inflammable air. I have performed this experiment, with different proportions of red precipitate, twenty times, and never met with any accident.

The inflammable air that Dr. Prieſtley uſed, muſt have been mixed with atmoſpheric air, or an exploſion would not have happened. That the pure air of the metallic calx is not diffuſed through the inflammable air which remains behind, appears evident from the following circumſtance.

If one drachm of red precipitate, is revived in ſixteen ounce meaſures of hydrogenous gas, twelve ounce meaſures

ſures of the inflammable air will diſappear, and the remaining four ounce meaſures, will not be diminiſhed by the teſt of nitrous air.

When the proportion of precipitate is large, and the inflammable air ſmall, after the inflammable air diſappears, the precipitate will give out its oxygen, and the air which remains, will be diminiſhed by the teſt of nitrous air.

This circumſtance has happened in ſome of the experiments of Dr. Prieſtley.

Another objection brought forward by Dr. Prieſtley is, that if hydrogen be nothing more than a component part of water, it never would be produced, but in circumſtances in which either water itſelf, or ſomething into which water is known to enter is preſent. He tells us, that upon heating finery cinder together with charcoal, inflammable air is produced, though according to the new theory no water is concerned.

The antiphlogiſtic chemiſts never ſaid, that hydrogenous gas could not be produced without water; for it is a conſtituent part of other bodies, as alcohol and ammoniac.

To aſcertain the quantity of hydrogenous gas, afforded by charcoal and finery cinder expoſed to a high degree of heat, an ounce of the ſcales of iron and the ſame quantity of charcoal, both reduced to a very fine powder, were ſeparately expoſed in covered crucibles, in an air furnace, well ſupplied with fuel, for five hours. They were then taken out of the fire, and mixed while *red hot* in a *red hot* iron mortar, were triturated with a *red hot* peſtle, formed of an iron ramrod, were poured upon a *red hot* piece of ſheet iron, and inſtantly put into a *red hot* gun barrel which was fixed in one of Lewis's black lead furnaces, and which communicated with the worm of a refrigeratory, a part of a hydropneumatic apparatus. Immediately after luting one end of the gun barrel to the worm, one hundred and forty-

two

two ounce meaſures, of inflammable air came over in torrents, mixed with one-tenth part of carbonic acid gas.

This experiment has puzzled all the advocates of the antiphlogiſtic ſyſtem, to whom it has been mentioned. Many conſider it as a powerful blow at the new doctrine, and every perſon explains it in a different manner.

Dr. Prieſtley's theory of it is very unſatisfactory, for he ſays the water from the finery cinder, uniting with the charcoal makes the inflammable air, at the ſame time that part of the phlogiſton from the charcoal, contributes to revive the iron.

This explanation will not do, for the iron is not revived, and it will not account for the production of the carbonic acid.

By conſidering the ſcales of iron, as a combination of iron, oxygen and water, there will be no difficulty in the buſineſs. The finery cinder ſupplies the coal with water, which is decompoſed; its oxygen unites with the coal and forms carbonic acid, while its hydrogen eſcapes, diſſolves part of the coal, and forms the carbonated hydrogen gas.

The celebrated Mrs. Fulhame, a lady whom I am proud to quote on this occaſion, is the only perſon I know, who ſeems properly impreſſed with the idea of the agency of water, in many chemical operations. This diſtinguiſhed lady, who is equally an example to her ſex, and an ornament to ſcience, has properly conſidered a metallic oxyd as a combination of a metal, oxygen and water.

There are other ſubſtances beſides finery cinder, which mixed with coal and expoſed to a red heat, yield hydrogenous gas and carbonic acid, in large quantities. Theſe airs may be obtained from the common ruſt of iron, or from any precipitate of iron, and coal which has ceaſed to yield air. They may alſo be procured, from the flowers of zinc and red hot coal.

One drachm of the flowers of zinc and twelve grains of red hot coal, which had ceaſed to yield air, being expoſed to a red heat gave fifty-eight ounce meaſures of hydrogenous gas, every portion of which was mixed with ſome carbonic acid.

One drachm of the precipitate of zinc, from a ſolution of white vitriol by ammoniac, expoſed to a red heat half an hour, when mixed while red hot, with red hot coal, which had ceaſed to yield air, gave fourteen ounce meaſures of inflammable air, mixed with carbonic acid.

The flowers and precipitate of zinc in theſe caſes, ſupplied the coal with water which was decompoſed. The metal was not revived.

SECTION III.

Of Finery Cinder or the Scales of Iron.

The antiphlogiſtic chemiſts conſider the ſcales, which the blackſmiths ſtrike off from red hot iron, to be iron partially oxygenated.

On the contrary Dr. Prieſtley ſuppoſes, that when iron is heated in oxygenous gas, it parts with its phlogiſton, and is converted into a ſubſtance reſembling finery cinder, but he will not allow that the air which diſappears in this proceſs, is imbibed by the iron, but only the water which was its baſe, while the oxygenous gas, he ſays, always goes to form the fixed air which is found in the experiment.

He declares that the quantity of carbonic acid, is quite ſufficient to take all the oxygenous gas that diſappears in the proceſs.

That the Doctor's ideas are not juſt on this ſubject, we have the moſt concluſive evidence.

If

If half a drachm of the filings of bar iron, are melted in twenty ounce meaſures of pure air, thirteen ounce meaſures of the air will be abſorbed by the iron, which will be converted into finery cinder. Half an ounce meaſure of carbonic acid gas will be produced.

Lavoiſier tells us, if the iron is pure, no fixed air will be obtained; and certainly Dr. Prieſtley will not ſay, that thirteen ounce meaſures of oxygenous gas enter into the compoſition of half an ounce meaſure of fixed air, which muſt be the caſe if his theory is true.

Here then are twelve and a half ounce meaſures of pure air, which cannot be accounted for according to the ſyſtem of Dr. Prieſtley, and when we ſee a ſubſtance produced, by melting iron in oxygenous gas, reſembling the ſcales of iron, in every property, and cannot account for the air which diſappears but by ſuppoſing it is imbibed by the iron, can we heſitate to pronounce, that the ſcales of iron contain oxygen.

The Doctor likewiſe ſuppoſes, that if oxygen was lodged in a calx of iron, it would dephlogiſticate the muriatic acid which minium inſtantly does, and which we grant does not contain a third as much pure air as a calx of iron.

To determine if finery cinder would dephlogiſticate the muriatic acid, four ounces of the acid, were diſtilled upon three ounces of the powdered ſcales of iron, without ſucceſs.

An attempt was alſo made to dephlogiſticate the acid, by diſtilling two ounces of the ſulphuric acid, upon three ounces of common ſalt, and as much of the ſcales of iron, without effect. The quantity of oxygen contained in theſe ſcales, muſt have been ſeveral hundred ounce meaſures.

Theſe trials however do not invalidate any thing, which has been advanced by the antiphlogiſtic chemiſts, for the oxygenation of the muriatic acid, does not depend ſo much upon the quantity of pure air contained in a calx, as upon its readineſs to give out this air to the acid; when the

attraction between the oxygen and metal is greater than between the oxygen and the acid, the acid will not be oxygenated. This is the caſe with iron.

A proof that the oxygenation of the muriatic acid, does not depend merely upon the quantity of oxygen contained in a calx is, that a drachm of manganeſe, which has been expoſed ſeveral hours to a red heat, and parted with the greateſt part of its pure air, will oxygenate the muriatic acid to a greater degree, than one ounce of mercurius cinereus, or the calx obtained by boiling cauſtic alkali upon turbith mineral, which contain thirty times as much pure air.

The Doctor likewiſe obſerves, if finery cinder was iron partially oxygenated, it would go on to attract more oxygen from the atmoſphere, and in time be converted into a ruſt of iron.

In order to determine if finery cinder would attract oxygen, the focus of the lens was thrown upon a quantity of it, confined in pure air, which was not abſorbed.

The ſteam of water was alſo paſſed over it for ſeveral hours, when red hot in an iron tube, but it ſuffered no alteration.

One ounce of it reduced to a fine powder, was expoſed to the action of atmoſpheric air upwards of twelve months, and ſprinkled with water ſeveral hundred times, and at the end of this time, was as free from ruſt, as when firſt expoſed, while an ounce of iron filings moiſtened with water, were covered with ruſt in three days.

I acknowledge that finery cinder cannot be converted into ruſt, but cannot ſee in what manner this makes againſt the antiphlogiſtic ſyſtem. When bar iron is converted into finery cinder, it parts with the ſmall quantity of coal it contained, and abſorbs oxygen and water.

The ruſt of iron differs from it materially, for it contains a portion of carbonic acid, and although the French chemiſts

chemiſts conſider this preparation as a carbonate of iron, I do not think it is entituled to this appellation, for one ounce of it yields but four ounce meaſures of fixed air, whereas the ſame quantity of the precipitate from green vitriol by the common pot-aſh of the ſhops, yields thirty-two ounce meaſures, and deſerves this character with more propriety.

A ſtrong proof that finery cinder contains oxygen is, that when it is heated in hydrogenous gas, it makes a large quantity of it diſappear, and I have ſhewn, that when metallic calces are heated in this air, that the diſappearance of the inflammable air, is always in ſtrict proportion to the pure air which they contain.

SECTION IV.

Of Carbonic Acid or Fixed Air.

According to the advocates of the antiphlogiſtic ſyſtem, the carbonic acid or fixed air, is a combination of charcoal and oxygen. They are of this opinion for two reaſons.

Firſt. If charcoal be plunged in a veſſel of oxygen gas, the whole of it will be conſumed, and carbonic acid gas will be produced.

Secondly. It is well known, that all the calces of mercury may be reduced without any addition, and will afford oxygenous gas, but if charcoal be mixed with them, the carbonic acid gas will be formed, and the charcoal will be conſumed.

Dr. Prieſtley in oppoſition to this opinion declares, that large quantities of fixed air have been procured in his experiments, where neither charcoal nor any thing containing it was concerned.

He

He ſays, when the pureſt malleable iron is heated in dephlogiſticated air, a conſiderable quantity of fixed air is formed. He tells us, in the firſt edition of his works, that there is but a ſmall portion of fixed air, formed in this proceſs.

Four experiments were made to determine this queſtion.

Melting by the burning lens, half a drachm of the filings of bar iron, filed for the purpoſe, in twenty-four ounce meaſures of oxygenous gas, which had been well waſhed in lime water, eleven ounce meaſures of the air were imbibed by the metal, and half an ounce meaſure of carbonic acid gas was produced.

One drachm of the ſame kind of filings, melted in thirty-ſix ounce meaſures of oxygenous gas, gave one ounce meaſure; one drachm and a half, an ounce and the eighth of an ounce meaſure; and two drachms, one ounce and the ſixth part of an ounce meaſure of carbonic acid gas.

One ounce of this iron in ſmall pieces, diſſolved in the ſulphuric acid and water, left a reſiduum of one half grain of charcoal.

There was evidently then not a ſufficient quantity of coal, contained in this iron, to account for the carbonic acid produced, by melting the iron in oxygenous gas, according to this analyſis, which is certainly, very imperfect.

The inflammable air, produced by diſſolving bar iron, in diluted ſulphuric acid, holds a portion of charcoal in ſolution, which is not eaſily detected, owing to the very ſmall quantity of coal, being equally diffuſed through a large quantity of hydrogenous gas, for the portion of coal cannot be more than three grains, in three hundred and ſixty-five ounce meaſures of inflammable air.

That the carbonic acid produced in this proceſs, does actually proceed from the charcoal contained in the metal, we have the moſt concluſive proofs, for the quantity of it obtained

obtained, is always in proportion to the coal contained in iron.

Bar iron contains a ſmall quantity of coal, compared to caſt iron, and by heating caſt iron in oxygenous gas, much more carbonic acid may be produced, than from bar iron.

Dr. Prieſtley ſays, that the plumbago contained in iron, could not be diſengaged from it in this proceſs, and if it could, it would not yield the hundredth part of the fixed air that is produced.

The charcoal contained in plumbago, can certainly be diſengaged from it with the greateſt eaſe, for every particle of it, is expoſed to a high degree of heat in oxygenous gas.

Two other arguments uſed by the Doctor, to prove that fixed air may be procured without charcoal, are:

That a great quantity of this kind of air, may be produced from heating a mixture of iron filings and red precipitate, or iron filings and turbith mineral.

Five attempts were made to obtain carbonic acid gas, by expoſing from half an ounce to an ounce of red precipitate, mixed with an ounce and two ounces, of the filings of bar iron, filed for the purpoſe, to a red heat, in a clean iron tube, without ſucceſs. The mercury of the precipitate was revived, no air was obtained, and the iron was reduced to a calx.

Mixing five drachms of the ſame kind of filings, and as much turbith mineral, and expoſing the whole to a red heat, the ſame reſult happened.

Having then recourſe to caſt iron, half an ounce of red precipitate was mixed with an ounce of the borings of cannon, and thirty-two ounce meaſures of air were obtained, eleven of which were fixed, and twenty-one inflammable.

One ounce of this iron, without any red precipitate, expoſed to a red heat, gave forty ounce meaſures of air, eight of which were fixed and thirty-two inflammable.

One

One ounce of theſe borings, diſſolved in ſulphuric acid and water, left a reſiduum of thirty-four grains, eighteen of which were coal and ſixteen ſilicious earth.

The carbonic acid gas obtained in theſe experiments, evidently proceeded from the coal, contained in the caſt iron.

The Doctor alſo obtained carbonic acid, by heating the charcoal of copper in dephlogiſticated air. This charcoal of copper is made by paſſing the ſteam of alkohol over red hot copper, and as it conſiſts principally of carbon, which is one of the component parts of alkohol, no argument can be adduced from it, in ſupport of his hypotheſis.

He alſo ſuppoſes that the fixed air, procured in animal reſpiration, is formed without charcoal, but as we feed upon vegetable ſubſtances, which contain coal, the carbonic acid, thrown out from the lungs, muſt be formed of this coal, uniting to the pure air taken into this viſcus in inſpiration.

SECTION V.

Of the Nitric Acid.

It is unneceſſary to refer Dr. Prieſtley, to the experiments of various chemiſts, to prove that the nitric acid is compoſed of oxygen and azote, as he muſt be well acquainted with every thing that has been done upon this ſubject.

As the Doctor obtains this acid at pleaſure, by decompoſing by the electric ſpark, a mixture of oxygenous and hydrogenous gaſes, in the proportion of a little more than one meaſure of the former to two of the latter, he ſuppoſes the acid is formed of theſe airs. But let us attend ſtrictly, to what takes place in experiments of this kind.

Thirty-

Thirty-two ounce meaſures of oxygenous gas, obtained from red lead and the ſulphuric acid, and ſixty-four ounce meaſures of hydrogenous gas, procured from the borings of cannon and diluted ſulphuric acid, both of which had been well waſhed in lime water, were introduced into a copper tube, and decompoſed by the electric ſpark. About one ounce of water, remained in the tube, which after the exploſion, was filled with an immenſe number of fine particles of matter, and which being collected upon a filter and analyſed, turned out to be copper.

The water was of a pale blue colour, and did not turn litmus paper red. Evaporated to dryneſs, it yielded one grain and a half of the nitrate of copper.

This experiment was repeated with the ſame kind of airs, and gave the ſame reſult.

Trying the hydrogenous gas from muriatic acid and zinc, and oxygenous gas, from red lead and ſulphuric acid in the ſame proportions, no difference took place.

Increaſing the quantity of oxygenous gas to forty ounce meaſures, and reducing the hydrogenous gas to fifty-ſix ounce meaſures, and excluding the water, nitrous acid was produced.

Repeating this experiment over diſtilled water, with the ſame quantity of oxygenous gas, obtained from red precipitate, and hydrogenous gas from malleable iron and diluted ſulphuric acid, the ſame quantity of nitrous acid was produced, and no muriatic acid was formed, as appeared by the acid not precipitating a ſolution of ſilver in nitric acid.

Introducing into the tube, thirty-two ounce meaſures of azotic gas, forty of oxygenous gas, obtained from the ſulphuric acid and manganeſe, and twenty-four of hydrogenous gas, from malleable iron by the diluted ſulphuric acid, the quantity of nitric acid did not appear to be increaſed.

Repeating the experiment with ſixteen ounce meaſures of azotic gas, fifty-ſix of oxygenous gas from red precipitate, and twenty-four of hydrogenous gas, from malleable iron and the diluted ſulphuric acid, the greateſt quantity of nitric acid was produced.

The acid obtained in any of theſe experiments, was not equal to three grains of concentrated nitric acid, conſequently the theory of Dr. Prieſtley muſt be wrong, for it is not probable, that fifty-ſix ounce meaſures of oxygenous gas, enter into the compoſition of three grains of nitric acid.

The Doctor is certainly right when he ſays, if phlogiſticated air be purpoſely introduced into the mixture of dephlogiſticated and inflammable air, it will not be affected by the proceſs. It is neceſſary however, to have regard to the quality and proportion of the oxygenous and hydrogenous gaſes; when theſe airs are pure, and contain no azotic gas, which is ſcarcely ever the caſe, water only will be formed. When azotic air is mixed with them, which it almoſt always is, that part of the oxygen, which does not unite to the hydrogen gas and form water, joins with the azotic gas and forms the nitric acid.

When carbonated hydrogen gas is uſed, carbonic acid, water and nitric acid will be generated.

That inflammable air does not enter into the compoſition of nitric acid is evident, for none of it, nor any thing into which it enters, as a conſtituent part, can be procured from the nitric acid, nor any combination of this acid with alkalies, earths or metals.

On the other hand, nitric acid may be ſeparated into its elementary parts, oxygenous and azotic gas; and if the acid was compoſed of pure and inflammable air, it could be made by heating red precipitate in inflammable air.

Mr. Keir who analyſed the liquor obtained by Dr. Prieſtley, from the exploſion of pure and inflammable air, ſuppoſed

ſuppoſed that the muriatic acid was always generated along with the nitrous.

As no muriatic acid was obtained in my experiment, when made over diſtilled water, it is probable that Dr. Prieſtley filled his tube with pump water, containing ſea ſalt, or that the water of his hydropneumatic tub contained ſome marine acid.

I cannot conclude this diſſertation, without acknowledging my obligations to Dr. Prieſtley, for his polite attention in ſhewing me a variety of experiments, when at his houſe in Northumberland, and for the inſtruction derived from reading his very valuable diſſertations, on different kinds of air.

Although I do not agree with the Doctor, in the theory which he has adopted, yet I conceive his entrance, on that branch of philoſophy, denominated pneumatic chemiſtry, will ever be conſidered, as marking an æra in the ſcience.